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NATURAL HYBRIDS AND BASIC CHROMOSOME NUMBER IN THE GENUS *ARUM*

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Abstract Two different *Arum* hybrids (2n = 70), one sterile, the other fertile, are described and compared. For the first time, the chromosome number 2n = 63 for the genus *Arum* has been observed. Some preliminary information about the karyology of these plants, their morphological characteristics, and their origin is given.
Key words Araceae, *Arum* hybrids, karyology, morphology.

INTRODUCTION

Only few different hybrids have up till now been recognised for the genus *Arum*. Several of them were recognised more by their karyological characteristics than by their phenotype. Three of them were established as pentaploid (2n = 70) and one as triploid (2n = 42).

The pentaploid plants have been described as hybrids between: 1. *A. italicum* Miller subsp. *neglectum* (F. Towns.) Prime and *A. maculatum* L. (Lovis, 1954; Prime, Buckle et Lovis, 1955); 2. *A. italicum* subsp. *italicum* and *A. maculatum* (Beuret, 1977); 3. *A. italicum* subsp. *italicum* and *A. apulum* (Carano) Bedalov (Bedalov, 1984). We suppose that the chromosome number 2n = 70 published for *A. italicum* (Alpinar, 1986, 1987) is also a pentaploid hybrid.

Terpó(1973) described a hybrid between *A. alpinum* Schott et Kotschy emend Terpó(1973) and *A. maculatum* L. but based on morphological characters only, while Harmes (1985) cited an artificial hybrid obtained by Prime between the same species: *A. orientale* Bieb. subsp. *danicum* Prime [= *A. alpinum* subsp. *danicum* (Prime) Terp (Terpó, 1973)] × *A. maculatum*. A natural triploid with 2n = 42 has been described as a hybrid between *A. alpinum* and *A. maculatum* by Beuret (1971, 1977) and Bedalov et Hodalova (1997). We suppose that the plants with 2n = 42 assigned to *A. maculatum* (Kononov et Mol'kova, 1974) as well as the 2n = 42 cited in the literature (Rothmaler, 1963) for *A. maculatum* are also triploid hybrids.

Prime (in Flora Europaea, 1980) noticed that *A. nigrum* Schott var. *apulum* Carano [= *A. apulum* (Carano) Bedalov (Bedalov, 1973a, 1973b, 1975, 1978, 1980, 1981, 1982, 1984, 1985; Bedalov et Hesse, 1989; Bedalov *et al*, 1991; Bianco *et al*, 1994) = *A. apulum* (Carano) Boyce (Boyce, 1993)] is probably a hybrid between *A. italicum* subsp. *italicum* with 2n = 84 and *A. orientale* Bieb. subsp. *lucanum* (Carano et Grande) Prime [= *A. cylindraceum* Gasparr., = *A. alpinum* Schott et Kotschy (Bedalov, 1973b, 1976, 1980, 1981, 1982, 1983, 1985; Bedalov et Gutermann, 1982; Bedalov et Hesse, 1989; Bedalov *et al*, 1993a, b, 1997 a, b; Bedalov et Fischer, 1995; Bedalov et Drenkovski, 1995; Bedalov et Bianco, 1997; Bedalov et Terp 1997; Bedalov et Hodalova, 1997)] with 2n = 28.

The rarity of hybrids belonging to the genus *Arum* in Eurasia, despite the high number of taxa recognised for the genus and their partial sympatrism, suggests either that many hybrids have simply been overlooked, or that the genetic pools of the different species are protected by some reproductive isolation mechanism.

MATERIAL AND METHODS

The plants investigated were cultivated in the Botanical Garden of the Faculty of Sciences, University of Zagreb, Croatia and the Botanical Garden of the University of Neuchâel, Switzerland. Mitotic chromosomes were studied in root tip cells. Roots were pretreated in a saturated water solution of paradichlorobenzene for about three hours, fixed in aceto – alcohol (1:3) and stained with aceto – carmine.

RESULTS AND DISCUSSION

In 1984, we described (Bedalov, 1984) a pentaploid hybrid with 2n = 70 chromosomes from the sympatric site of 《Masseria La Cattiva》 near San Michele di Bari (Italy). Its karyological and morphological characters, as well as those of its presumed parents, allowed us to identify it as *Arum apulum* (2n = 56) × *A. italicum* subsp. *italicum* (2n = 84).

Since then, our entire *Arum* collection has been cultivated in the botanical garden of Zagreb, under conditions where some spontaneous hybridisation could not be excluded.

Among our material, we were surprised to find a large number of pentaploid plants (Fig. 1). Furthermore, the specimens with 2n = 70 could be separated into two groups, according to their morphology and to their reproductive characters. Their main characters are summarised in the comparative table (Table 1).

The first group, mostly sterile, corresponded to the pentaploid hybrid described earlier (Bedalov, 1984). The second group, mostly fertile, could mainly be distinguished by the characters of the spadix (Table 1). The presence of normally developed male flowers, as well as of normally developed sterile upper flowers (staminodes) arranged in two or three whorls (Fig. 4) contrasted with the characters of the first sterile group (Fig. 3). We also observed that in both groups the female flowers exhibited no obvious morphological signs sterility, compared to the flowers of the parent species.

Many more observations will of course be necessary, especially of the leaf and tuber morphology, before a final conclusion as to the origins of the plants may be drawn.

Up till now, the male fertility of the 2n = 70 specimens has been determined by the aspect of the pollen. The ability of this hybrid to produce male gametes that can fertilise a female gamete still remains to be demonstrated.

Until now, the female fertility of the plants with 2n = 70 has been determined by the observation of the fruit, that appear to be well developed in only some specimens. Germination experiments have been carried out and some plantlets obtained.

Among the plants cultivated in Zagreb, we also found a specimen with a yet unknown chromosome number for the genus *Arum*: 2n = 63 (Fig. 2). The chromosome number 2n = 63 has already been noted for some Araceae species, like: *Calla palustris* L. (Ehrenberg, 1945), *Anthurium pulchellum* Engler (Mookerejea, 1935; Sharma, 1956) and *Rhodospatha blanda* Schott (Sharma, 1956). For the genus *Arum*, our present finding raises more questions than it answers. The culture conditions of our collection make it impossible for us to ascertain the natural origin of the specimen (near San Michele di Bari).

Although this first hypothesis seems to us the most probable, a spontaneous hybridisation in the botanical garden cannot be excluded. The chromosome number 2n = 63 tends to confirm the hypothesis of an at least partial female fertility of the 2n = 70 specimens of group 2.

In its vegetative parts the 2n = 63 specimen shows some differences with the 2n = 70 hybrids. The leaves are sagittate to hastate, thicker than in the 2n = 70 hybrids, with more or less convergent lateral lobes, and less visible nervation. The tuber is discoid vertical in shape (Fig. 7), while in *Arum* 2n = 70 (Table 1) the tuber is somewhat discoid oblique in sterile plants (Fig. 5), and more or less rhizome like in

fertile plants (Fig. 6).

Two processes can explain the origin of the number 2n = 63. The first (Table 2, a) implies a backcross of a 2n = 70 specimen, at least partially fertile, with a 2n = 56 specimen, most probably *A. apulum*. The number 2n = 63 would result from the fusion of an either aneuploid or euploid gamete n = 35 from the first parent, with a n = 28 gamete, from the second parent. The second (Table 2, b) requires a fertilisation between two individuals with the same chromosome number 2n = 70. In both cases, the somatic number 2n = 63, a multiple of 7, could also be a fortuitous event.

If the chromosomal number 2n = 70 really represents a pentaploid valence (x = 14), the gametes produced by such a specimen must necessarily be aneuploids. Generally speaking, aneuploidy is better tolerated in high polyploids.

The basic number of the Araceae has been discussed previously by several authors, particularly by Larsen (1969), Marchant (1972) and Petersen (1989 and 1992). Different authors, such as Mookerjea (1955), Sharma (1956), Bhattacharya (1974), Subramanian et Munian (1988), have reported 2n = 14 for other allied genus but most of these observations concern occasional individuals among a population with other cytotypes. Garbari's (1964) interesting finding of specimens with 2n = 14 chromosomes, concerns individuals belonging to *Arisarum proboscideum* (L.) Savi and growing in a mixed population alongside 2n = 28 types. Such sympatrism does not appear very compatible with a primary situation, dating back to polyploidisation. A recent, secondary sympatrism would indicate modifications of the environment, generally not favourable to the conservation of ancient diploids, originating from the Tertiary. Nevertheless for one species, *Ulearum viridispadix* Bogner, 2n = 14 represents the only known chromosome number (Petersen, 1989).

Having revised all the karyological data regarding the Araceae, Petersen concludes that the arguments in favour of the number x = 7 are weak. For her, the data concerning the number 2n = 14 《turn out to be caused by haploidy and miscounts》or 《due to reduction from higher numbers》.

Petersen's conclusion is probably correct. The genus *Arum* derives from an ancestor with 2n = 28, where x = 14 represents a secondary basic number. From a biogeographical point of view, the evidence of an ancient basic number x = 7 will only really be ascertained when all the specimens from at least one population, belonging to a species of *Arum* (or to a very closely related genus) and originating from a major centre of flora conservation, will be shown to have 2n = 14 chromosomes, regular meiosis and offspring with constant karyological characteristics. However, till now, there is no evidence supporting this assumption. Nevertheless, the occurrence of the chromosome numbers 2n = 63, 2n = 42 or 2n = 70, this last one partially fertile, does suggest some genetic balance of the karyotypes multiples of seven, a possible reminiscence of an old basic chromosome number of x = 7.

CONCLUSIONS

Our results do not allow us to bring decisive arguments in favour of the existence of a basic number x = 7 in the genus *Arum*. The existence of fertile plants with 2n = 70 and of a specimen with 2n = 63 only are an incentive for further investigation of the evolution of the chromosome number in the genus *Arum*.

Table 1. The Comparative Characters of Two Hybrid Groups in *Arum*

Sterile Hybrids, 2n = 70 (Fig. 3, 5)	**Fertile Hybrids, 2n = 70 (Fig. 4, 6)**
sterile upper flowers absent or rarely weakly developed.	sterile upper flowers normally developed, in 2 or 3 whorls.
male flowers mostly reduced, rudimentarely developed, sterile.	male flowers present, normally developed, producing (mostly) fertile pollen.
female flowers well developed.	female flowers well developed.
somewhat discoid - shaped tuber, usually oblique oriented to one side.	more or less rhizome - like tuber, producing the new main shoots at the top of the rhizome.

Table 2. Two Processes of Fortuitous Aneuploids

a. Backcross	2n=70 →	aneuploid gamete with x=14 or euploid gamete with x=7?	n=35 → 2n=63	Fortuitous aneuploid or perissoploid with x=7?
	2n=56 →	euploid gamete with x=14 →	n=28 ↗	
b. $F_1 \times F_1$	2n=70 →	aneuploid gamete with x=14 →	2n=63 fortuitous aneuploid	
	2n=70 →	aneuploid gamete with x=14 →		

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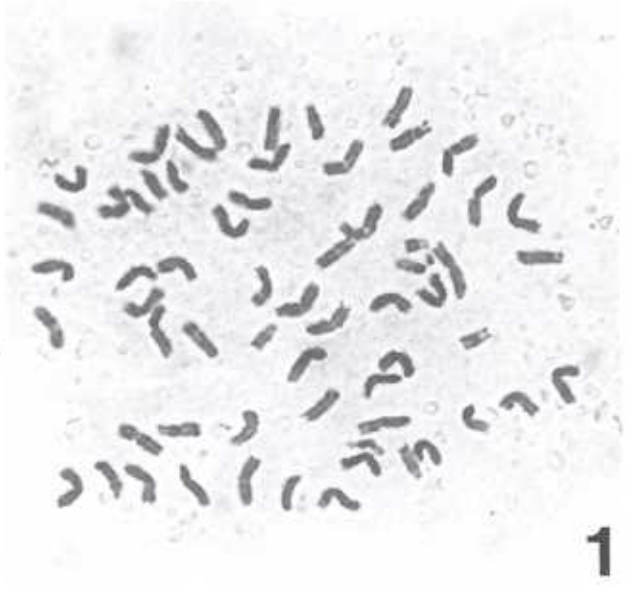

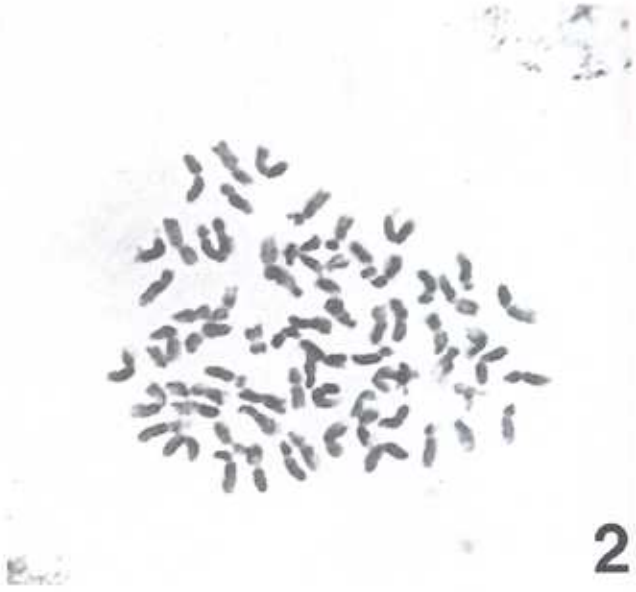

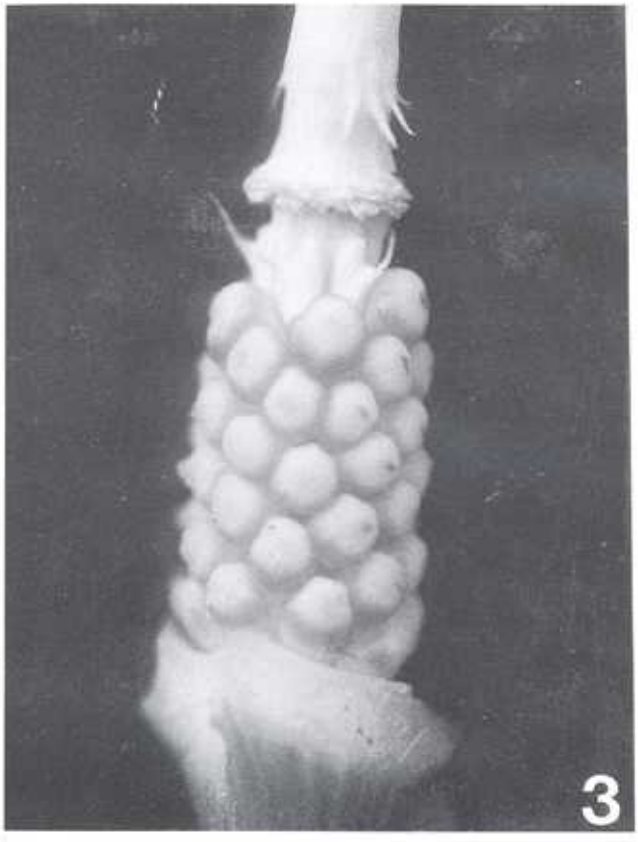

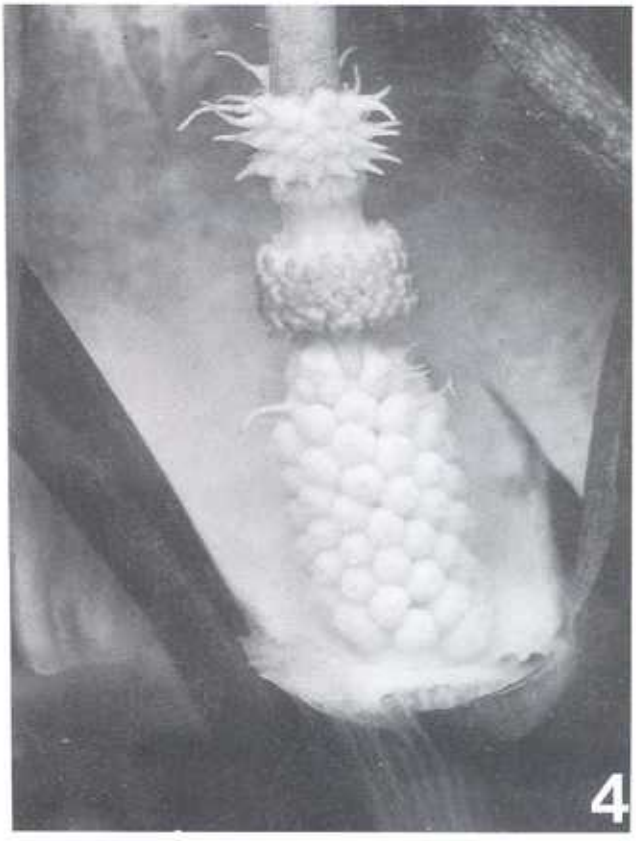

1. *Arum*, 2n = 70; 2. *Arum*, 2n = 63; 3. *Arum*, 2n = 70, sterile; 4. *Arum*, 2n = 70, fertile.

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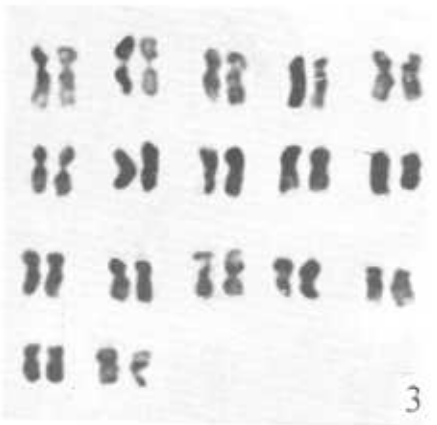

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